



IBM Solid Logic Technology



Shown actual size, these tiny transistors and diodes—each measuring 28-thousandths-of-an-inch square—
and the modular circuit building block (right) are the basic elements of Solid Logic Technology.

Solid Logic Technology

Solid Logic Technology—SLT—is a microelectronic circuit technique developed by engineers and scientists at the International Business Machines Corporation's laboratories and manufacturing facilities in the Hudson River valley communities of Poughkeepsie and East Fishkill, New York.

SLT brings to microelectronic technology the kind of reliability that is borne of rigidly specified component values, precise circuit interconnections, and the manufacturing accuracy made possible by fully mechanized production.

With the development of SLT circuits and production techniques, IBM has made a major contribution toward applying microminiaturized electronics, on a practical basis, to data processing systems.

IBM System/360—a single system for business and scientific problem-solving—uses SLT in its logic and storage circuitry and benefits from the compactness, speed, and reliability provided by this technology.

The Solid Logic Technology Concept

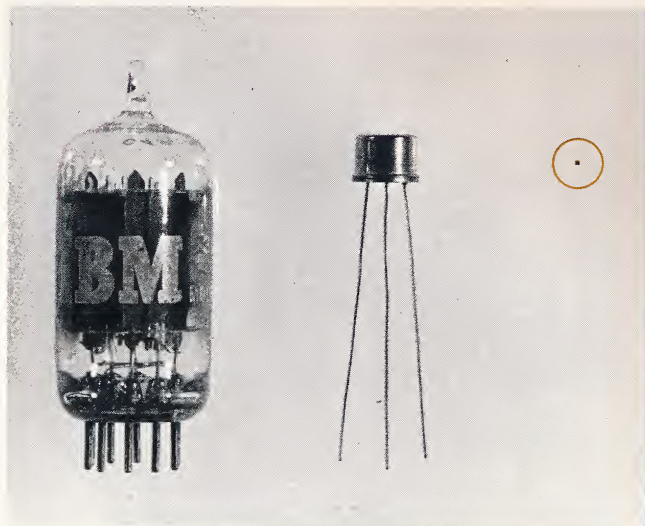
The "Solid" part of SLT refers to the microscopic transistors and diodes used in this circuit technique. These solid state devices act like vacuum tubes, but the electrical impulses travel through a solid material instead of a vacuum.

"Logic" is the function of the circuit module, individually and in combination with other circuit modules. Each has connectors, a circuit pattern, resistors, transistors and/or diodes.

When an electronic circuit is performing a

logic function, it is switching, amplifying, and/or controlling electrical inputs to electronically calculate logic algebra. A computer's ability to solve programmed problems is, to a great extent, determined by the design of its logic circuitry.

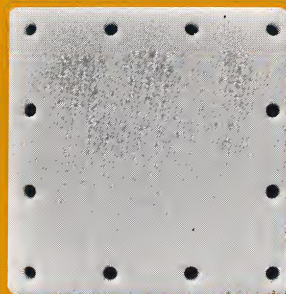
Thus, through Solid Logic Technology, IBM engineers, scientists, and technicians have adapted a particular circuit concept to meet today's needs for high-performance, low-cost computer components.



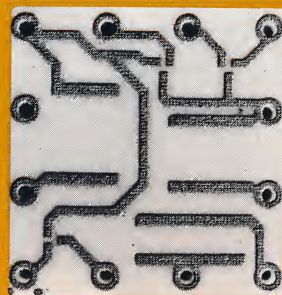
Progress in electronics has moved from the vacuum tube to the transistor to the tiny dot of an SLT "chip" transistor.

The SLT module. The squares (1) are tiny chip transistors and diodes which are attached at junctions on the circuit pattern (2). The large dark areas (3) are resistors. The two small dots at lower left are for orientation during fabrication. In the SLT manufacturing process, a bare ceramic substrate (top left) is outfitted with a circuit pattern, resistors, and connecting pins. Then, the substrate is dipped into solder, resistors are trimmed, chip transistors and diodes are attached and the unit is sealed in a protective metal shell.

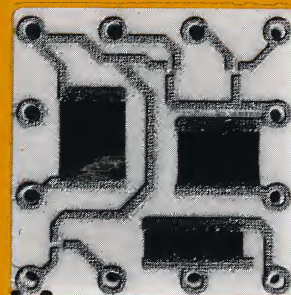
SLT module fabrication



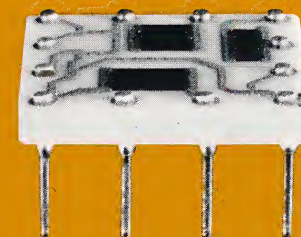
Bare substrate.



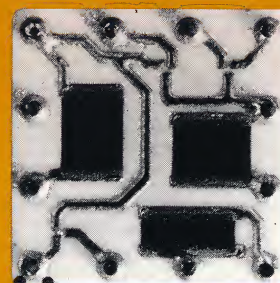
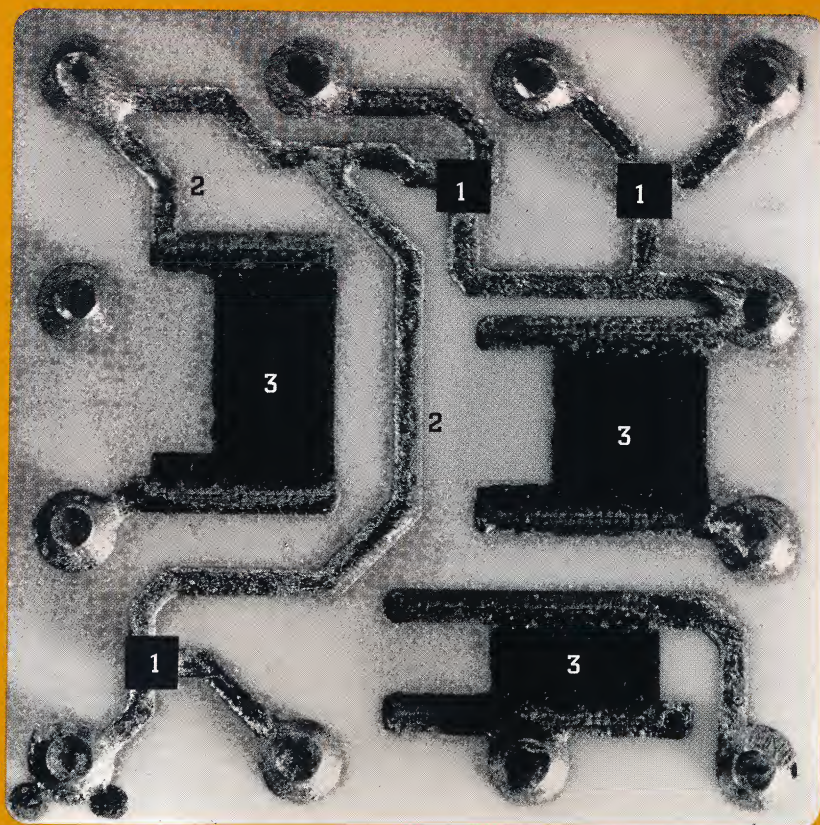
Print circuit pattern.



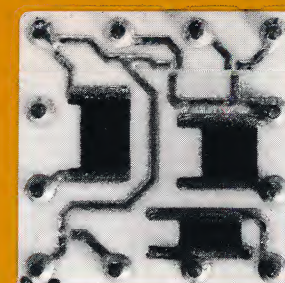
Print resistors.



Insert connecting pins.

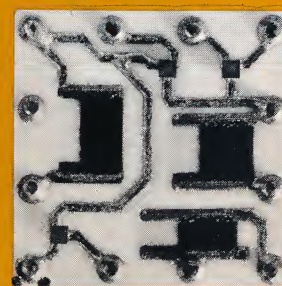


Dip into solder.

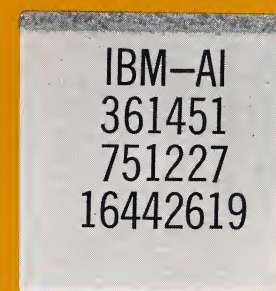


Trim resistors.

Attach transistor
or diode chips.



Seal in metal shell.



The SLT Chip

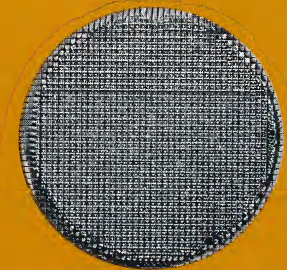
The tiny chip component of the SLT circuit is the single most significant development that led to incorporating this technology in general purpose data processing systems. Each transistor or diode chip is approximately the size of the period at the end of this sentence.

By existing technological standards, it is relatively easy to produce microscopic transistors and diodes . . . until you come to the problem of protecting the chip. The main accomplishment of the SLT chip is that it is protected by a thin coating of glass over the entire device (except for a metallurgical system which provides the electrical contacts). Ordinarily, tran-

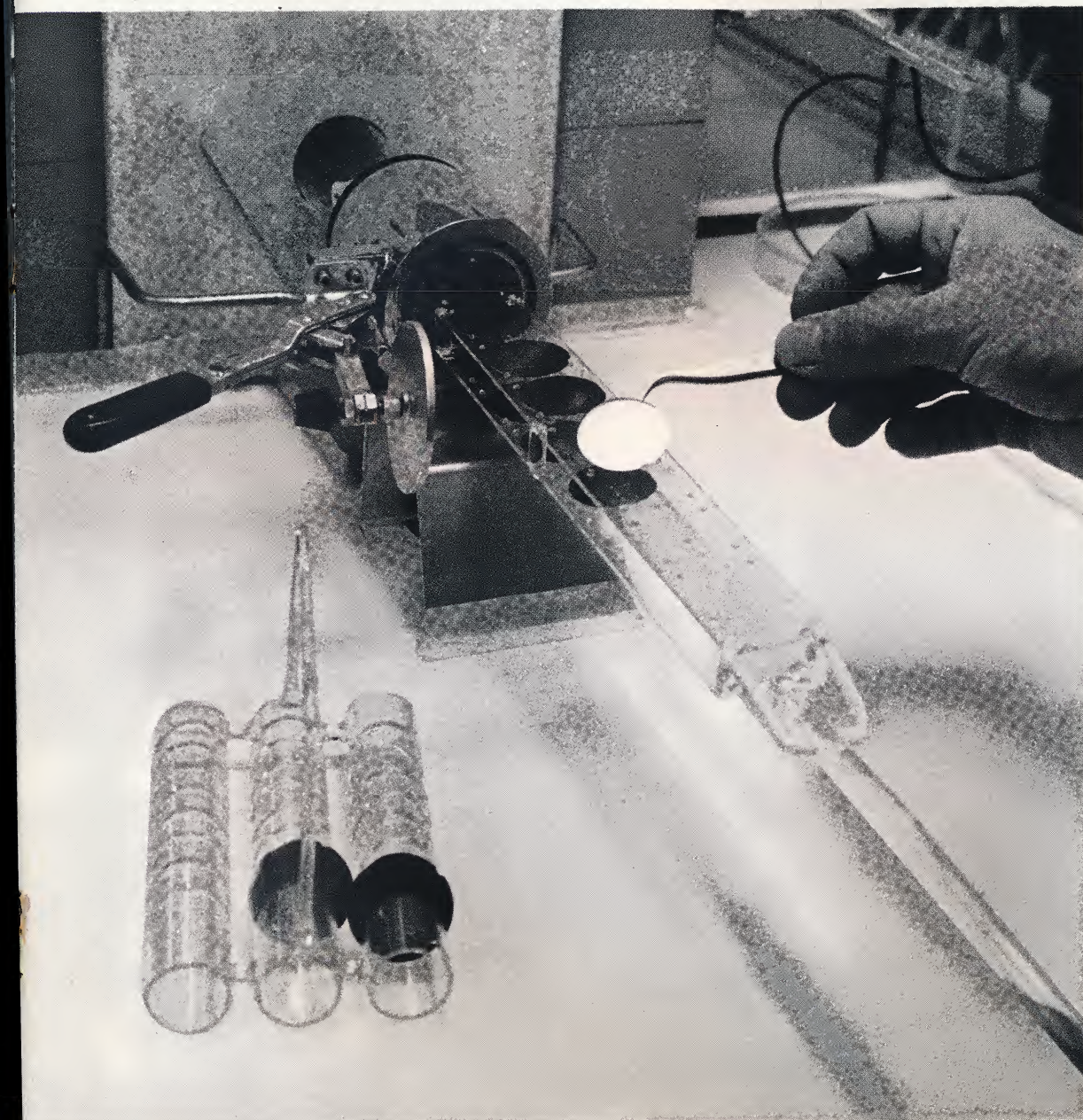
sistors are encased in a hermetically sealed, protective metal can.

The chips do not need the metal cans, lead wires, whiskers, etc., that are used in fabricating conventional transistors. Additionally, fewer parts result in higher reliability.

In fabricating these chips, more than a thousand are made, simultaneously, on a 7-thousandths-of-an-inch-thin silicon crystal wafer about the size of a half-dollar. The chips are manufactured using vapor growth, graphic arts and photoprinting, diffusion, and evaporation processes to form the active regions and the contacts of the devices.

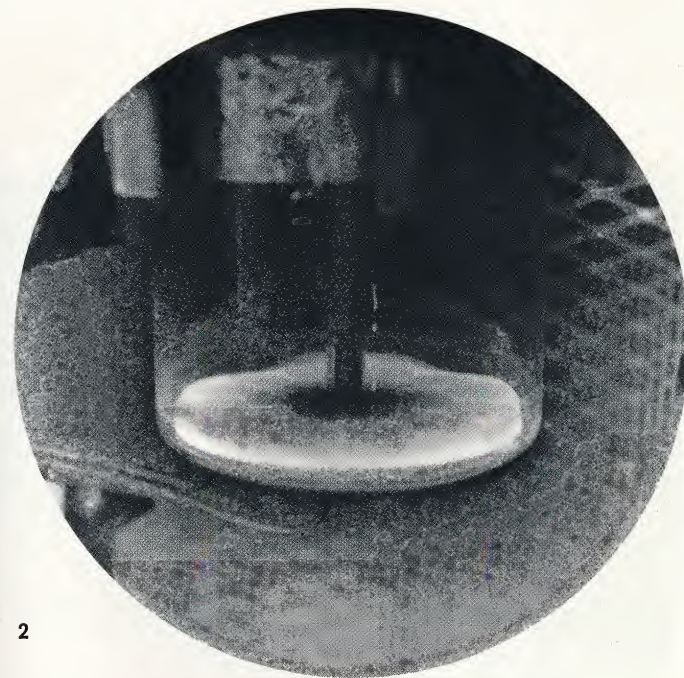


The actual size of the wafer (above) with more than 1,000 chip components. A photomicrograph of the wafer (left) shows several completed chips—each with three metallic contacts.



SLT chips (below) compared to a pencil eraser. The reduction in the size of the transistors and diodes is the result of a glassing operation which protects each device. After bonding a 60-millionths-of-an-inch-thin layer of glass to the surface of each wafer, they are removed from the furnace (left), ready for the final process steps.

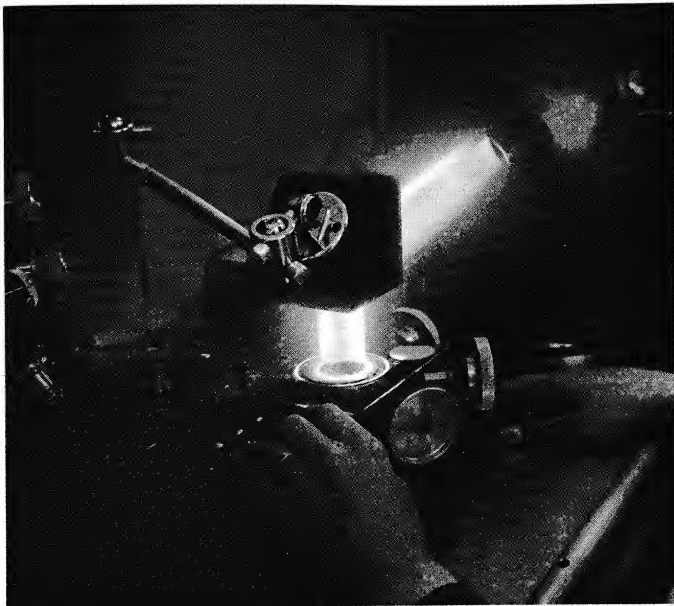




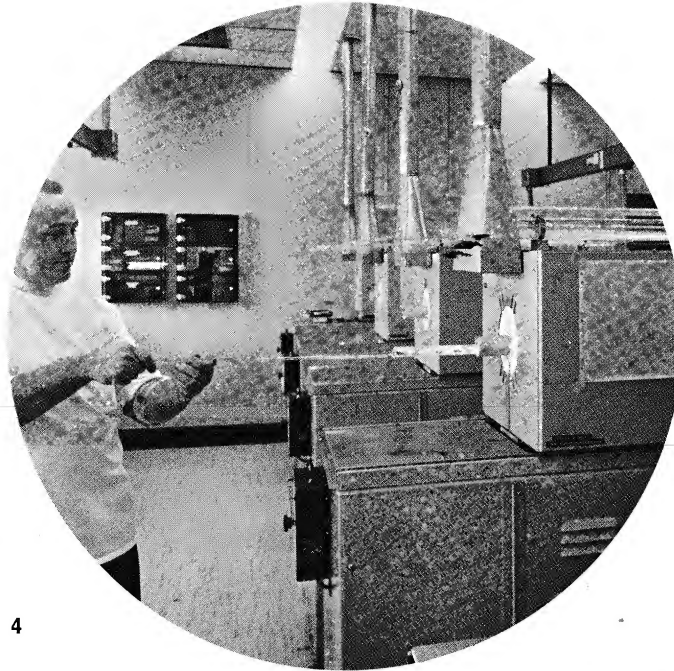
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SLT chip fabrication

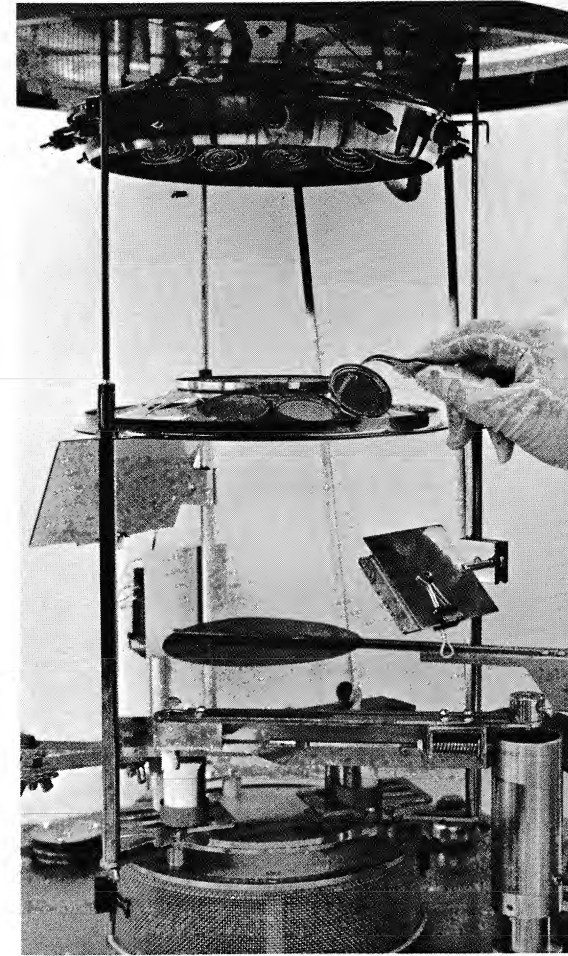
1. A technician checks the chamber in which silicon crystals are grown, while a finished rod of silicon cools before being processed into wafers. 2. A very thin layer of epitaxial silicon is vapor-grown onto the surface of the wafers in a vacuum chamber. 3. Areas which will become the electrical regions of each chip are photographically formed on the wafers. 4. Gas diffusion of the wafers takes place in these furnaces. 5. Wafers are removed from a vacuum chamber after metallic evaporation. 6. Tiny metallic spheres—about 5-thousandths-of-an-inch in diameter—are spread over each wafer to provide the electrical contacts between the circuit pattern on the module and the active regions of the chip. After three spheres are joined to each device, the wafer is diced into over 1,000 chips. 7. The final testing and sorting of each chip is done automatically. In 3/10ths of a second a chip can be given as many as 40 electrical tests.



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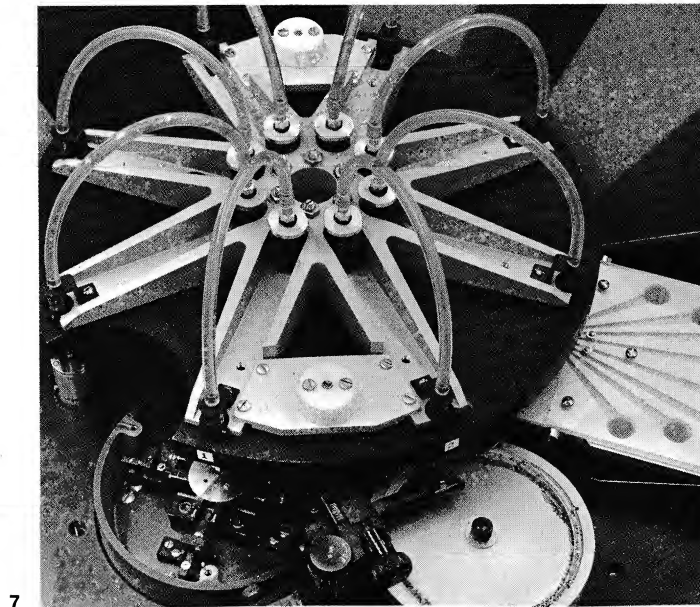
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The SLT Module

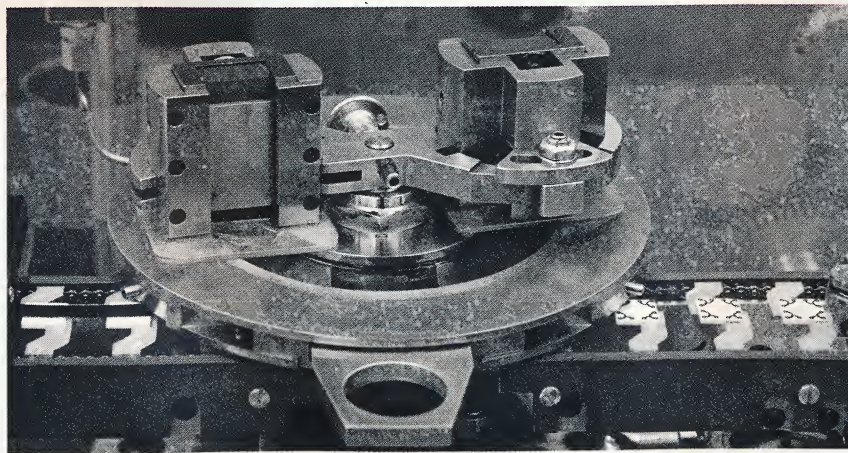
The SLT module is a circuit package which was designed to accommodate the microelectronic transistor and diode chips. These circuits serve as basic logic building blocks and as driver circuits for the storage units.

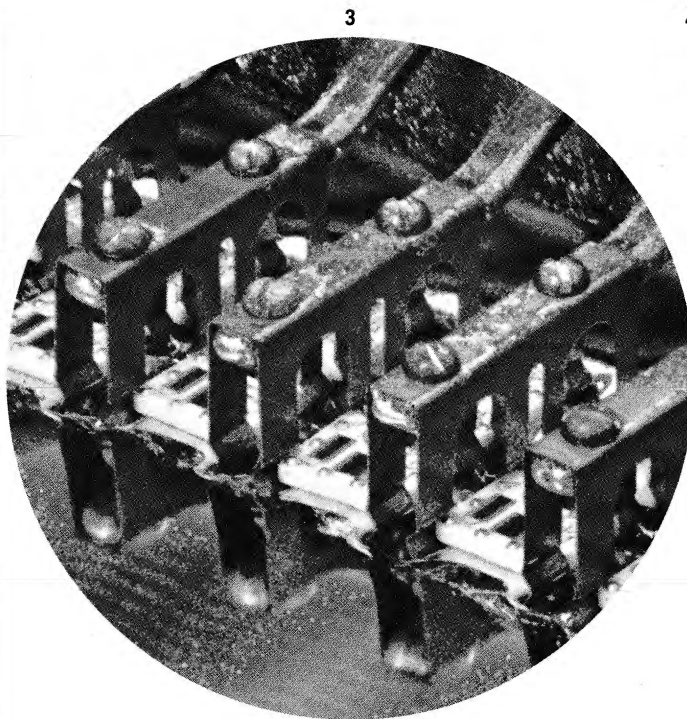
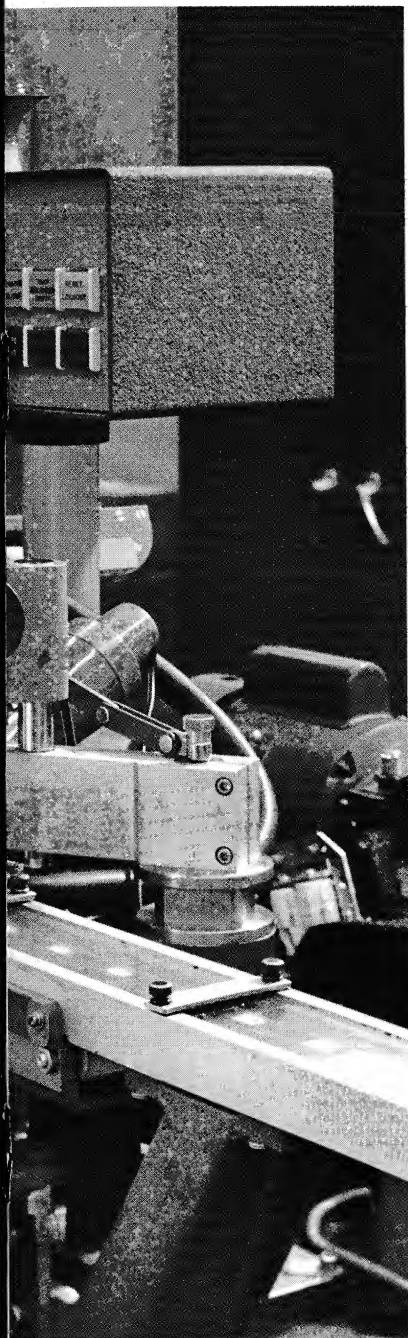
Each module is a ceramic square—measuring less than a half-inch on a side—which can carry a complete computer logic circuit. There are more than 40 different types of modules that handle inputs and outputs for basic and supporting circuit functions.

SLT modules do not require lengths of wire to connect electronic components or the myriad parts often associated with computer

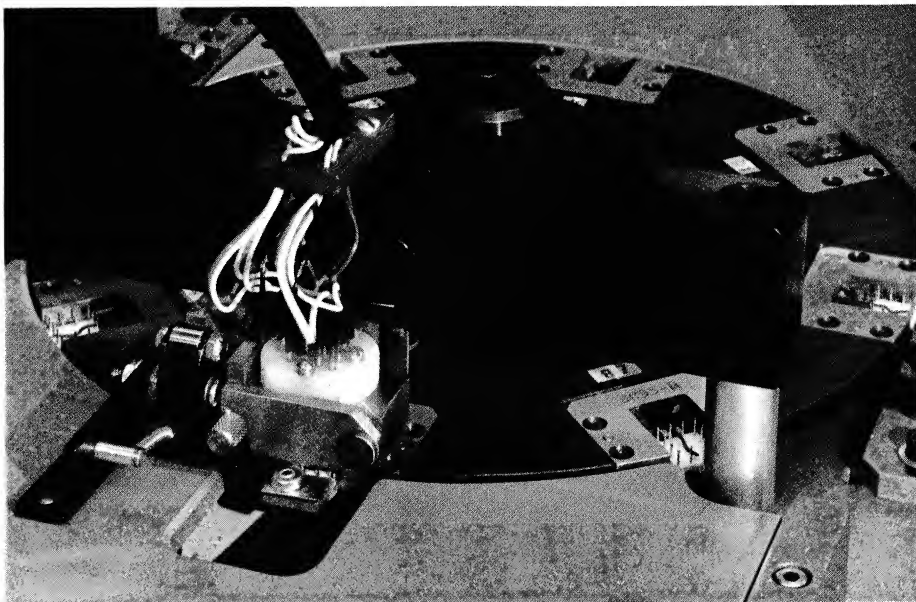
switching circuits. The fabrication of SLT modules is completely mechanized, using automatic equipment designed by IBM engineers. Circuit patterns and resistors are screen-printed onto the ceramic squares, 12 copper connecting pins are inserted around the perimeter, and the transistor or diode chips are precisely positioned by a specially designed machine. Then, each module is sealed in a protective aluminum shell.

The basic component, then, is the module. In order to harness its capabilities, it must be used as a building block in higher levels of circuit packaging.





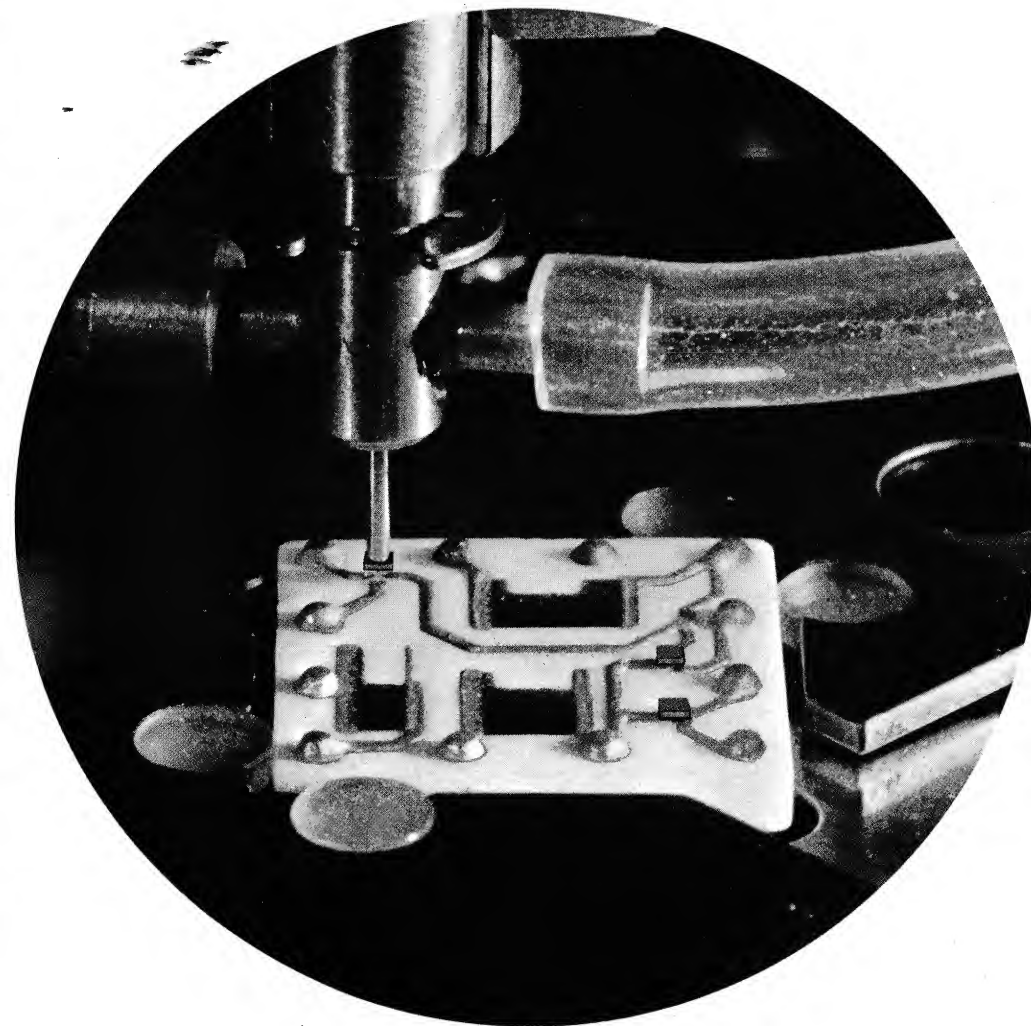
1. Circuit patterns and resistors are screen-printed onto SLT substrates using a rotating head that "squeegees" special inks through a metal mask (or screen) to print the desired pattern. 2. As the screen-printing machine operates—at a rate of better than one substrate per second—the printed patterns are periodically inspected to control ink flow and precise pattern registration. 3. After connecting pins have been inserted, substrates are dipped into solder baths to ensure good electrical connection and to provide the solder on the circuit pattern that will hold the chip transistors and diodes in place. 4. The tinning (solder bath) machine carries racks of 32 substrates through a seven-step, 28-second cycle.



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1. Tiny nozzles—located beneath this rotary worktable—blast a mixture of extra-fine sand and air at each resistor to tailor them to precise electrical values (resistance). 2. Each resistor trimming machine has two sets of “sandblasting” equipment built into the console. 3. The SLT circuit is completed by positioning chip transistors and diodes at specific locations on the substrate. The automatic chip positioning machine can complete circuits at a rate of better than one per second.

The ASLT Module



Some of the chips used in ASLT circuits contain two and three ultra-high-speed transistors in one. The ASLT triple-transistor chip is only twice the size of the single-transistor chip. The close interconnection of these transistors on a single silicon chip helps ASLT circuits to function in less than 1.5 nanoseconds—about three times faster than the fastest SLT circuits.

For ultra-high-speed requirements, IBM circuit engineers developed the fastest logic circuits designed for scientific problem-solving.

ASLT (Advanced Solid Logic Technology) modules incorporate many innovations in circuit design to meet the special demands of scientific data processing.

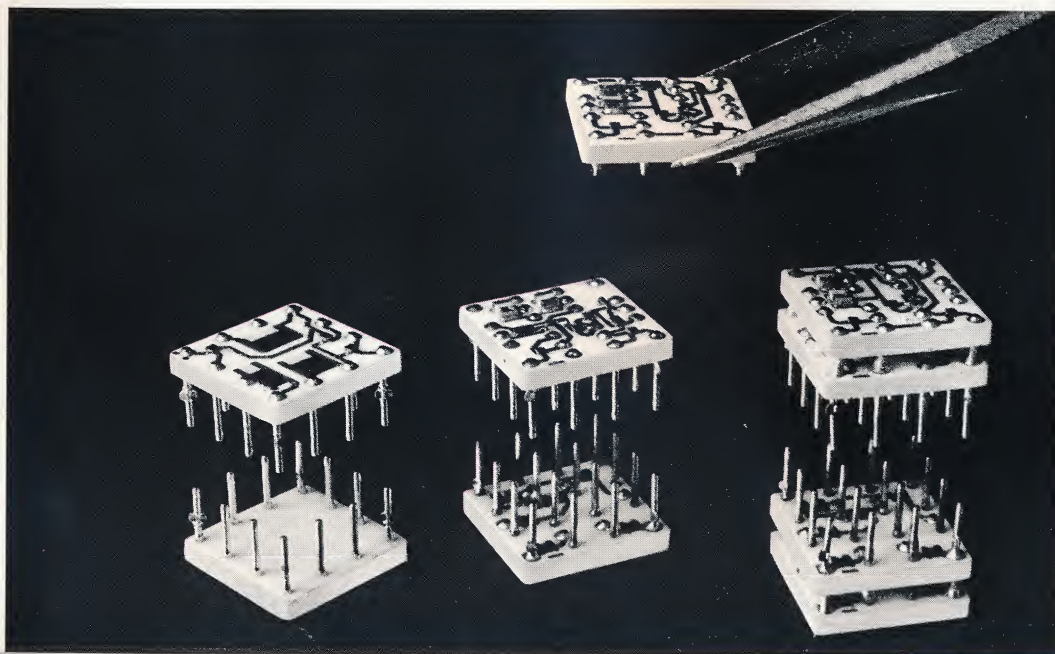
ASLT circuits can function in less than 1.5 nanoseconds (billionths-of-a-second)—about the time it takes light to travel 16 inches. This ultra-high speed is the result of the dense packaging of components on the substrates' tops and bottoms, the "piggyback" mounting of one substrate upon another, and the use of a form of circuit logic called current steering.

These densely packed "piggyback" circuits

shorten the distance an electronic impulse must travel, cutting the time it takes to perform a calculation.

In current steering logic, no diodes are used, and electronic impulses are directed by ultra-high-speed transistors over one of two possible circuit paths. As the computer operates, current is always flowing through the circuit ("on" condition), rather than going from "on" to "off" in the course of a calculation.

In addition to advances in speed and circuit density, ASLT represents significant improvements in interconnection techniques, logical flexibility, wireability, and fan power—the number of other circuits with which a single circuit can communicate electronically.



This photograph of an SLT module (left) and an ASLT module (right) on a mirror shows the basic physical differences between them. An ASLT module has components on both surfaces of its two substrates. The top surfaces contain circuit patterns, chip capacitors, and single-, double-, or triple-transistor chips. On the bottom surfaces are circuit patterns and screen-printed resistors. Soldered pins interconnect the "piggybacked" ASLT substrates.

Circuit Packaging

An adaptable and flexible hierarchy of circuit packaging steps permits both SLT and ASLT modules to achieve their logic and storage capabilities. These levels of packaging are the vital assembly steps that take microminiaturized circuits out of the realm of development and special applications and into the practical production of general purpose computers.

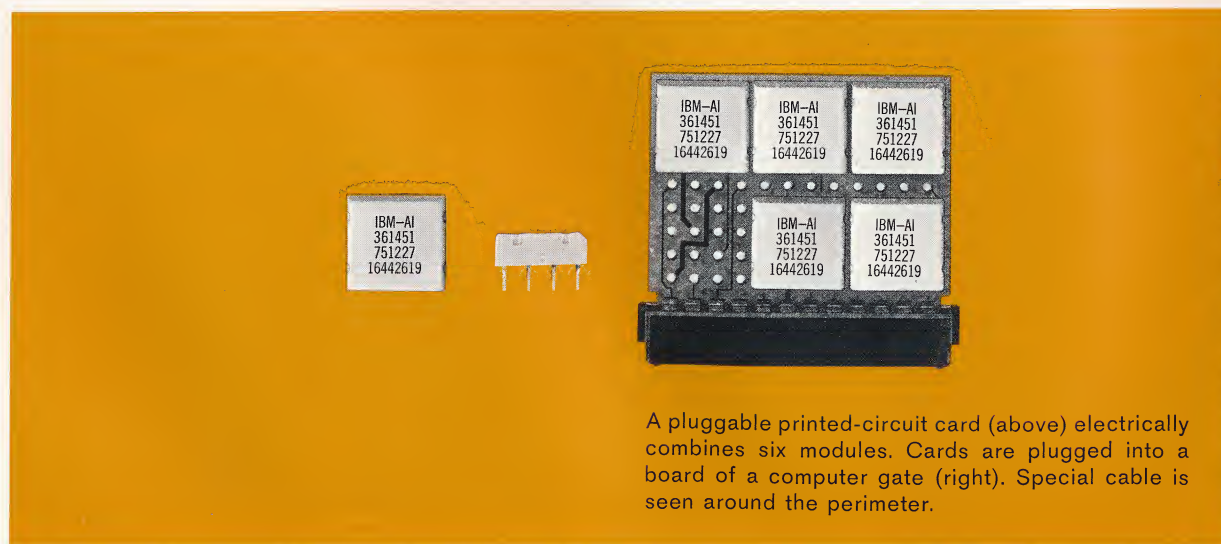
Modules are soldered to printed-circuit logic cards of various sizes in a manner determined by the particular performance desired. That is, these cards have circuit configurations that dovetail with the functions of the circuits provided by the modules.

Then, the logic cards are plugged into computer boards (in effect, larger cards) which have printed circuits on them and conform to

the particular circuitry of the pluggable cards.

After completing these packaging steps, the computer boards are assembled into multi-board gates, which are interconnected by specially designed cables. The number of gates determines the logical performance capabilities of the computer. Varying packaging techniques are used for storage-logic and storage-driver circuits.

The cabling of the SLT gate provides another innovation in computer assembly. A flat cable, consisting of two layers of conducting wires each measuring 7-thousandths-of-an-inch in diameter, replaces the ordinary bulky cable. This special cable minimizes signal disturbances, and is particularly compatible with microminiaturized circuitry.

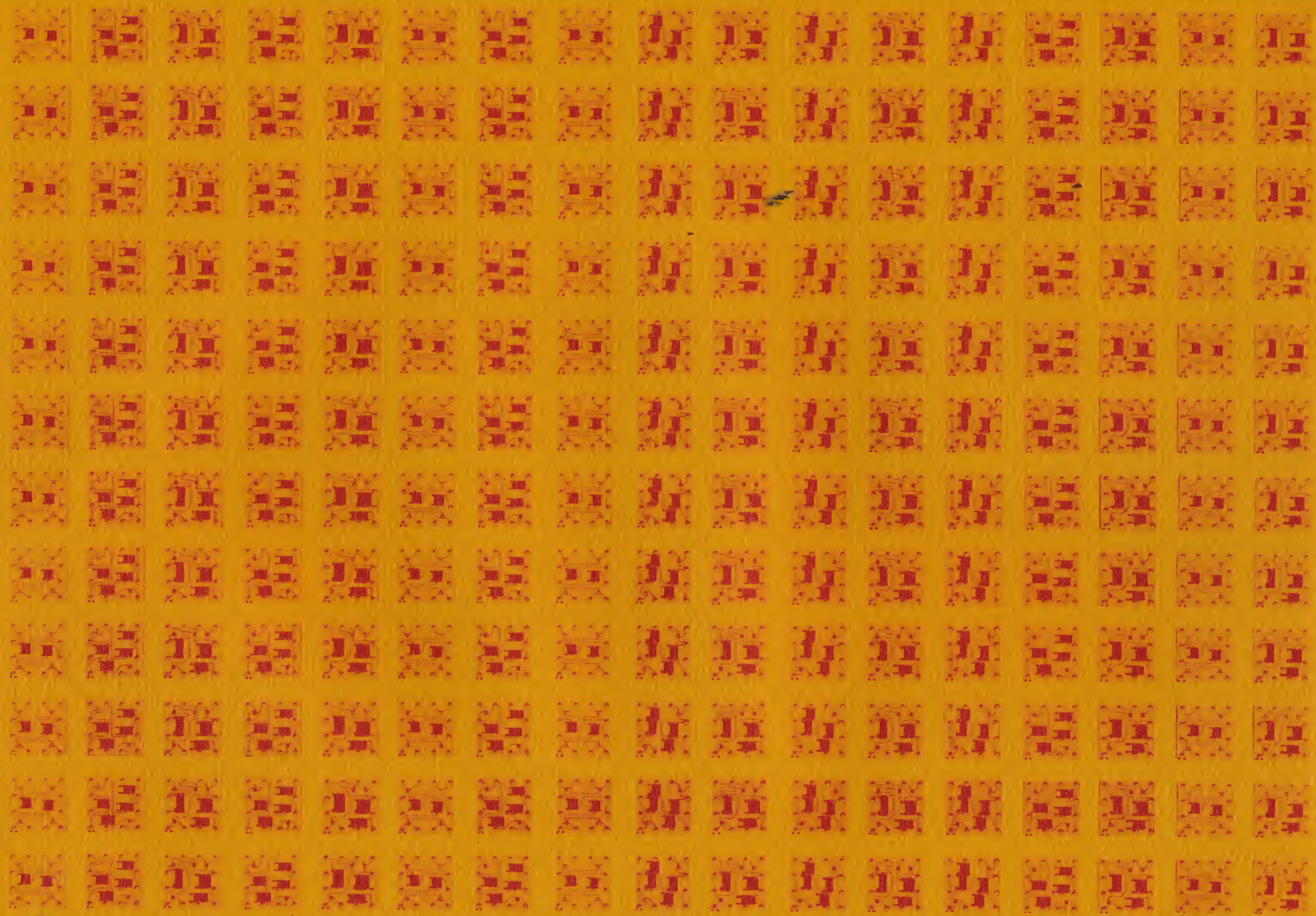


A pluggable printed-circuit card (above) electrically combines six modules. Cards are plugged into a board of a computer gate (right). Special cable is seen around the perimeter.





One of the IBM data processing systems which is based on Solid Logic Technology.



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